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TRANSPORT CROSS SECTIONS FOR ALKALI PLASMAS USING THE PSEUDO-POTENTIAL METHOD

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1. INTRODUCTION

Plasmas, liquid and solid simple metals are examples for systems of charged particles which in general can be considered as consisting of a "lattice" of heavy ions and nearly free electrons (electron gas). The interaction between these elementary particles is given by Coulomb's law and will determine the microscopic (scattering and transport processes) as well as the macroscopic properties as, e.g., electrical and thermal conductivity, thermopower or the specific heat capacity of the system.

However, it is well known that in such dense systems as mentioned above the interaction between the charged particles deviates from the pure Coulomb potential (Ω_0 : system volume, e_c, e_d: charge of species c ,d)

$$V_{cd}(q) = \frac{4\pi e_c e_d}{\Omega_0 q^2} \tag{1.1}$$

due to two reasons:

i) The long-range character of the Coulomb potential leads to many-particle effects as, e.g., dynamical screening of the charge carriers or to the formation of bound states (see for a review, e.g.[1,2] for plasmas and [3] for solids).

ii) The scattering centres (ions) can no longer be considered to be point charges, because the core electrons modify the potential in the vicinity of the ion.

Dynamical screening is usually treated in Random Phase Approximation (RPA), which leads to a dynamically screened potential of the form

$$V^s_{cd}(q,\omega) = \frac{V_{cd}(q)}{\epsilon(q,\omega)}, \tag{1.2}$$

where $\epsilon(q,\omega)$ is the dielectric function. In solids, the RPA-dielectric function is given by the Lindhard expression [4]. Applying the concept of RPA to plasmas too and considering the case of statical screening ($\omega = 0$) as well as the limit $q \to 0$ (weak scattering), the well-known Debye potential (see, e.g.[1,2]) is obtained:

$$V^s_{cd}(q) = \frac{V_{cd}(q)}{1+\kappa^2/q^2}, \quad \kappa^2 = 4\pi\beta \sum_b n_b e_b^2, \tag{1.3}$$

where $\kappa = r_D^{-1}$ is the inverse screening length (r_D: Debye radius, $\beta = 1/(k_B T)$: inverse temperature, $b = e, i$: species, e_b: charge, n_b: density of species b).

On the other hand, the deviations from the Coulomb potential $V_{cd}(q)$ (1.1) due to the ion structure can be considered using the pseudo-potential method (PPM), see, e.g. /3,5/, which has been successfully applied to calculate structure, transport or thermodynamic properties of solid and liquid simple metals.

The first simple pseudo-potentials (PP) of Hellmann /6/ of Ashcroft /7/ were further improved by a more complicated PP-ansatz (Abarenkov-Heine /8/, Shaw /9/) or numerically self-consistent calculations (Zunger and Cohen /10/) which lead to a parameter-free PP.

These deviations from the pure Coulomb potential are known in plasma physics as nonideality effects and are important in that range of the phase diagram, where the nonideality parameter $\Gamma = \ell / r_D$ ($\ell = e^2/(k_B T)$: Landau length) is greater than unity. Measurements have, e.g., shown that in this region calculations within the Born approximation using the Debye potential (1.3) yield a lower bound for the electrical conductivity /11/. An increase of the conductivity and a better agreement with the experimental data is expected if, e.g., i) higher order scattering effects (higher than 1st Born approximations, t-matrix calculations) and ii) additional short range forces due to the ion structure are taken into account within the theoretic approach /11/.

Especially, the last problem will be investigated in this paper considering the transport properties of nonideal alkali plasmas. The transport properties are mainly determined by the microscopic scattering processes between the plasma constituents. A characteristic quantity for the description of these processes is the transport cross section $Q_T(E)$ which is defined in the next section. Furthermore, the PPM is applied for the calculation of the transport cross sections and the influence of the ionic structure effects on the transport properties is discussed. One expects, that in dilute plasmas these effects are vanishing because the mean distances between the particles are large. The microscopic scattering process is in this case nearly independent from the choice of the short-range part of the PP and only described by it's long-range behaviour which is given by the Debye-potential (1.3). However, this independence from the choice of the short-range interaction will be lost in the region of higher densities. Then, the mean distances between the particles are smaller and one has to account for the special form of the interaction potential in the vicinity

of the ions. The PPs are introduced in section 3. The results for the transport cross sections using these PPs are shown in section 4.

2. TRANSPORT CROSS SECTIONS

The transport cross section for electron-ion scattering $Q_T(E)$ is related to the differential cross section $dQ/d\Omega$ in the following way /12/:

$$Q_T(E) = 2\pi \int_0^\pi \frac{dQ}{d\Omega}(1-\cos\theta)\sin\theta \, d\theta. \tag{2.1}$$

The information on the scattering process is contained in $dQ/d\Omega$, which can be expressed in terms of the scattering amplitude $f(\theta)$ by the equation

$$\frac{dQ}{d\Omega} = |f(\theta)|^2. \tag{2.2}$$

Applying the relation between the scattering phase shifts δ_ℓ and the scattering amplitude $f(\theta)$ /12,13/

$$f(\theta) = \frac{1}{2ik} \sum_{\ell=0}^{\infty} (2\ell+1)(e^{2i\delta_\ell}-1) P_\ell(\cos\theta), \tag{2.3}$$

where $P_\ell(\cos\theta)$ are the Legendre polynomials, one obtains for the transport cross section $Q_T(E)$ (2.1) the following expression ($E = k^2$):

$$Q_T(E) = \frac{4\pi}{E} \sum_{\ell=0}^{\infty} (\ell+1)\sin^2(\delta_\ell - \delta_{\ell+1}). \tag{2.4}$$

The calculation of the scattering phase shifts δ_ℓ can be performed numerically for the electron-ion-potentials under consideration. However, due to the long-range character of the interaction potentials which is treated in the Debye model, the convergency of the scattering phase shifts δ_ℓ is poor so that a large number ($\ell \cong 80$ /14,28/) of the phase shifts is necessary for the determination of the transport cross sections.

For elastic electron-ion scattering processes, equation (2.1) can be written as a function of the transfer-momentum q which is defined by $\sin(\theta/2) = q/(2k)$ ($\vec{q} = \vec{k} - \vec{k}'$, $|\vec{k}| = |\vec{k}'|$, $\vec{k}, \vec{k}'$: momentum of the scattered electron in the initial/final state). Then, the scattering amplitude $f(q)$ can be expressed in terms of the t-matrix by the following equation /12/:

$$f(q) = -\frac{1}{4\pi} \sum_k t(k, k-q), \quad t = V + VG^0 t. \tag{2.5}$$

In the weak scattering limit which is considered in this paper a perturbation expansion can be applied to the determination of the scattering amplitude $f(q)$. Solving the Lippmann-Schwinger-equation (2.5) (G°: Green function of free particles) in lowest order with respect to the electron-ion potential V (1st Born approximation), the scattering amplitude is given by the Fourier transform of this interaction potential, so that for the transport cross section $Q_T(E)$ the following result is obtained:

$$Q_T(E)^{Born} = \frac{4\pi a_0^2}{E^2} \int_0^{2k} |\tilde{V}_{ei}(q)|^2 q^3 dq\,. \tag{2.6}$$

The Fourier transform $\tilde{V}_{ei}(q)$ is defined via

$$\tilde{V}_{ei}(q) = \frac{1}{4\pi e^2} \int \frac{d^3\vec{r}}{\Omega_0} e^{i\vec{q}\cdot\vec{r}}\, V_{ei}(\vec{r}). \tag{2.7}$$

Equation (2.6) was applied to calculate transport cross sections for elastic electron-ion-scattering in the Born approximation using different PPs $V_{ei}(\vec{r})$ which are introduced in the next section. The calculations were performed for the alkali metals in the energy range $0.01 \leq E \leq 4$ (in ryd) and for different plasma densities $0.001 \leq \kappa a_0 \leq 0.1$ ($10^{16} \leq n_e \leq 10^{20}$). Since the results, for the transport cross sections $Q_T(E)$ depend weakly only on the species, explicit results are shown only for the case of Na.

3. PSEUDO-POTENTIALS (PP)

The special form of the short-range interaction between the electron and the ion can be chosen in different ways which gives rise to the existence of a great number of more or less complicated PPs /5/. Another problem is the determination of the free parameters which are contained in the PP-ansatz. They are often fitted to reproduce macroscopic properties as, e.g., the electrical conductivity. Another more general approach is to solve the Schrödinger equation for the isolated two-particle system and to fit the free parameters of the electron-ion-PP so, that the energy spectrum of the related two-particle bound state (atom) is reproduced. This procedure was applied in this paper.

The Debye potential (1.3) which is a standard model for the description of the interaction between charged particles in plasmas is considered at first. It takes into account only statical screening effects and no short-range modifications of the pure Coulomb potential. However, it is used to describe

the long-range behaviour of the following PPs and therefore necessary for comparison.

1) Debye Potential

$$V^D(r) = -\frac{e^2}{r} e^{-\kappa r}\,, \quad V^D(q) = -\frac{4\pi e^2}{q^2+\kappa^2}\,. \tag{3.1}$$

The Hellmann potential /6/ was frequently used for the determination of thermodynamical, optical and transport properties of alkali plasmas /1,15,16/. This PP describes a hard-core behaviour of the ion at small distances $r \to 0$ and therefore cannot allow for penetration effects of the electron into the ion. For large distances r the model of Debye screening was applied by multiplying the unscreened PP by the factor $\exp(-\kappa r)$.

2) Hellmann Potential

$$V^H(r) = -\frac{e^2}{r} e^{-\kappa r}(1 - A e^{-Br}), \quad V^H(q) = -4\pi e^2\left(\frac{1}{q^2+\kappa^2} - \frac{A}{q^2+(B+\kappa)^2}\right). \tag{3.2}$$

The PPs of Ashcroft /7/ and Heine-Abarenkov /8/ replace the original $1/r$ -behaviour of the interaction potential at small distances $r \to 0$ by a constant value V_0 for r less than a model radius R_M (notice, that $V_0^{(A)} = 0$ and $V_0^{(HA)} \neq 0$). This reflects the electronic properties of simple metals where the ions, besides the valence electron, consist of energetically deep lieing and filled electron shells. Furthermore, the screening of the PPs was treated by replacing the Coulomb by the Debye potential for distances r greater than R_M.

3,4) Ashcroft, Heine-Abarenkov Potential

$$V^{A,HA}(r) = \begin{cases} -V_0^{(A,HA)}\,, & r \leq R_M \\ -\frac{e^2}{r} e^{-\kappa r}\,, & r > R_M \end{cases}\,, \tag{3.3}$$

$$V^{A,HA}(q) = -\frac{4\pi}{q^2} V_0^{(A,HA)} [\sin(qR_M)/q - R_M \cos(qR_M)] - \frac{4\pi e^2}{q^2+\kappa^2} e^{-\kappa R_M}[\cos(qR_M) + \frac{\kappa}{q}\sin(qR_M)]. \tag{3.4}$$

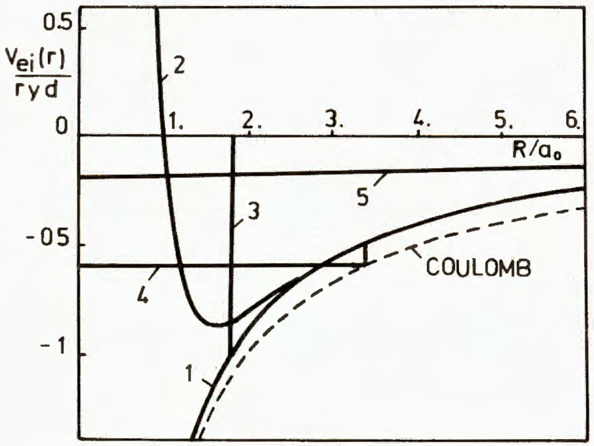

Fig. 1. The electron-ion pseudo-potentials $V_{ei}(r)$ (in ryd) as a function of the distance r (in units of the Bohr radius a_0) for Na at a density of $\kappa a_0 = 0.05$ ($n_e = 2 \cdot 10^{19} cm^{-3}$): (1) Debye potential (3.1), (2) Hellmann potential (3.2), (3) Ashcroft potential (3.3), (4) Heine-Abarenkov potential (3.5). The Thomas-Fermi potential (3.6) of Mayev [20] is identical with the Debye potential (1) and only for $r < a_0$ stronger attractive. The broken line denotes the Coulomb potential.

The treatment of screening effects is also possible in the q-space. Then, one has to divide the Fourier transform of the unscreened PPs (3.2-4) by the dielectric function $\epsilon(q, \omega)$. In the case of Debye screening $\epsilon(q) = 1 + \kappa^2/q^2$, only small deviations between these two different methods are expected [14].

The PPs (1-4) are shown in fig. 1 as a function of the distance r (in units of the Bohr radius a_0) for Na at a density of $\kappa a_0 = 0.05$ ($n_e = 2 \cdot 10^{19} cm^{-3}$). The behaviour at large distances $r > 5a_0$ is given by the Debye potential (broken line: Coulomb potential) whereas for lower distances different models for the short-range interaction are significant. The curve (5) indicates the Glauberman-Yuchnowski potential[17] which is also often used to describe the interaction between charged particles in plasmas[18]. This PP is of the Hellmann-type with $A = 1$. The parameter B is determined by the condition [19]

$$\beta V^{GY}(r=0) = -2B \equiv -6, \tag{3.5}$$

where a temperature of $T = 5000$ K was chosen which is typical of numerous experiments of alkali-plasmas [18].

Another possible treatment of the ion structure is given by the Thomas-Fermi model which allows for penetration effects of the scattered electron into the ion. At small distances $r \to 0$, the full charge Z of the ion core gives rise for a stronger attractive potential compared with that of the singly charged ion. A possible PP for this model was given by Mayev [20] who proposed also a PP of the Hellmann-type (3.2) with the following parameters:

$$A = Z_i - Z, \quad B = \frac{1.8 Z^{4/3}}{Z - Z_i} \tag{3.6}$$

($Z_i = 1$: charge of the ion, Z: charge of the ion core, $Z_{Na} = 11$). Another, more complicated PP within the Thomas-Fermi model was introduced by Green, Sellin and Zachor [21]. Chin [14] has performed calculations of the transport cross section for Cs with this potential.

The Table shows different parameter sets for the PPs (2-6) of Na. As discussed above, the choice of parameters for (2.4) reproduced the spectroscopic properties of the Na-atom (ground state energy E_{3s} transition energy E_{3s-3p}).

Table

Parameters for the PPs (2-6) of Na (in atomic units)

	PP	Parameter	Reference
(2)	Hellmann	$A = 10.9$ $B = 2.4$	/22/
(3)	Ashcroft	$V_0^{(A)} = 0$ $R_M = 1.8147$	/7/
(4)	Heine-Abarenkov	$V_0^{(HA)} = 0.61$ $R_M = 3.403$	/8a/
(5)	Glauberman-Yuchnowski	$A = 1$ $B = 3k_BT$, $T = 5000K$	/19/
(6)	Thomas-Fermi	$A = -10$ $B = 4.4035$	/20/

The electron-ion transport cross section (2.6) was calculated for different PPs (1-6). The following analytical results (in ryd^2 $2\pi a_0^2$) are obtained for the Debye-(3.1) and Hellmann potential (3.2):

$$E^2 Q_T^D(E) = \ln(1+z) - \frac{z}{z+1}, \quad z = 4E/\kappa^2,$$

$$E^2 Q_T^H(E) = \ln(1+z) - \frac{z}{z+1} + A^2\left[\ln(1+y) - \frac{y}{y+1}\right] \tag{3.7}$$

$$- \frac{2A}{(B+\kappa)^2 - \kappa^2}\left[(B+\kappa)^2 \ln(1+y) - \kappa^2 \ln(1+z)\right], \quad y = \frac{4E}{(B+\kappa)^2}.$$

Notice, that the results for the Hellmann-like PPs (5,6) are identical with equation (3.8), if the relevant parameters are applied (see the table).

The transport cross sections for the Ashcroft and Heine-Abarenkov PP (3.3,4) were calculated numerically.

4. RESULTS FOR THE TRANSPORT CROSS SECTIONS

Figs.2 (A-C) show the electron-ion transport cross section $E^2Q_T(E)$ in 1st Born approximation as a function of the energy E for different densities $\kappa a_0 = 10^{-3}, 10^{-2}, 10^{-1}$. The qualitative behaviour of the curves doesn't vary with increasing density. Due to the stronger screening of the electron-ion interaction, the transport cross sections are lowered by a factor of 2 (for high energies $E > 1$ ryd) to 10 (for lower energies $E \approx 0.01$ ryd) in the density range from $\kappa a_0 = 10^{-3}$ to $\kappa a_0 = 10^{-1}$ ($n_e = 10^{16}\,cm^{-3}$ to $n_e = 10^{20}\,cm^{-3}$).

For low energies $E < 0.1$ ryd, the results of the Hellmann potential (2) and of Mayev's [20] Thomas-Fermi potential (6) converge against the Debye-transport cross section (1). In this energy region the influence of the long-range interaction dominates which is given by the Debye potential for all PPs (2-6). Short-range interactions become important with increasing energies at a fixed density. Though the Hellmann potential (2) has a strong repulsive character and the Thomas-Fermi potential (6) an opposite attractive one for small distances (see fig.1), their transport cross sections show in the region $E > 1$ ryd nearly the same behaviour and reach values which are much greater than those of the Debye-transport cross section. Thus, the model of hard-core repulsion (2) at small distances and the opposite Thomas-Fermi model which allows for penetration effects into the ion yield the same results compared with the Debye-model in the high-energy region. Characteristic deviations between these two models are obtained in the intermediate energy range 0.1 ryd $< E < 1$ ryd where the Hellmann-transport cross sections are nearly constant whereas the Thomas-Fermi-transport cross sections increase monotonously.

The results for the Ashcroft (3) and Heine-Abarenkov-(4) transport cross sections $E^2Q_T(E)$ show a constant behaviour over the whole energy range. Furthermore, they are 2...4 times smaller than the Debye-transport cross sections (dependent on energy). These PPs are due to their special form of the short-range interaction weaker than the Debye potential (see fig.1) and therefore, yield lower transport cross sections. It is interesting that the Ashcroft- (3) and Heine-Abarenkov-(4) transport cross sections differ only slightly in the region of higher energies $E > 1$ ryd whereas for energies $E < 1$ ryd

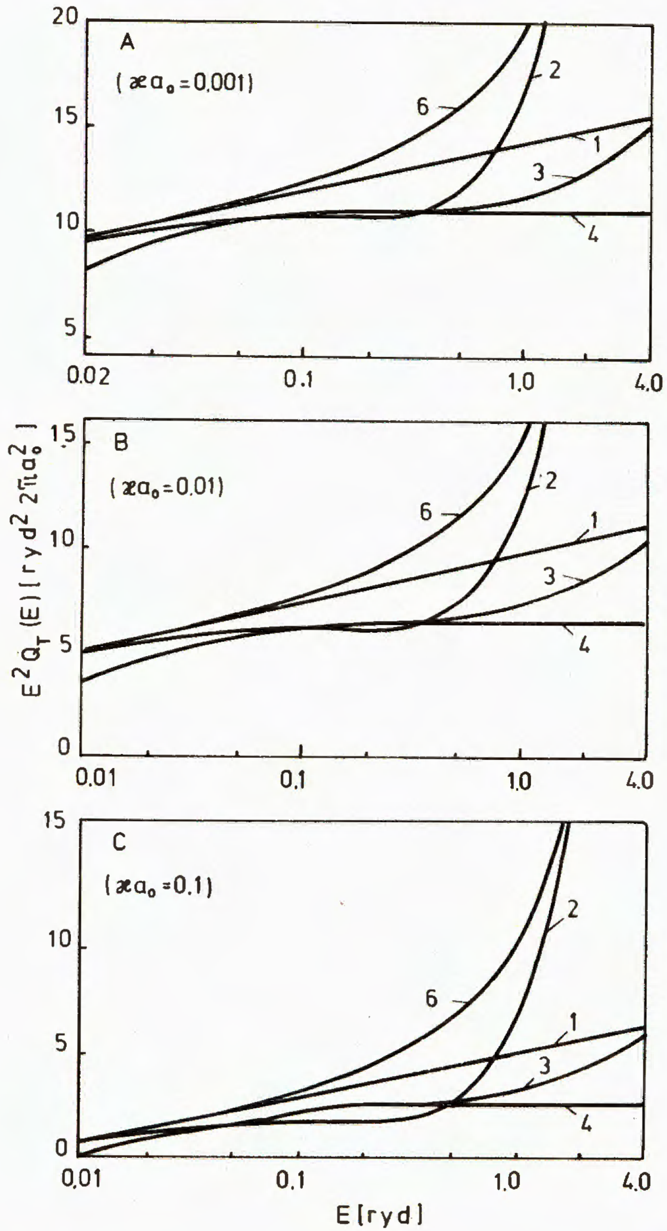

Fig.2. The electron-ion transport cross section $E^2Q_T(E)$ in 1st Born approximation (2.6) as a function of the energy E for different densities: A – $\kappa a_0 = 0.001$, B – $\kappa a_0 = 0.01$, C – $\kappa a_0 = 0.1$. The notation is the same as in fig.1.

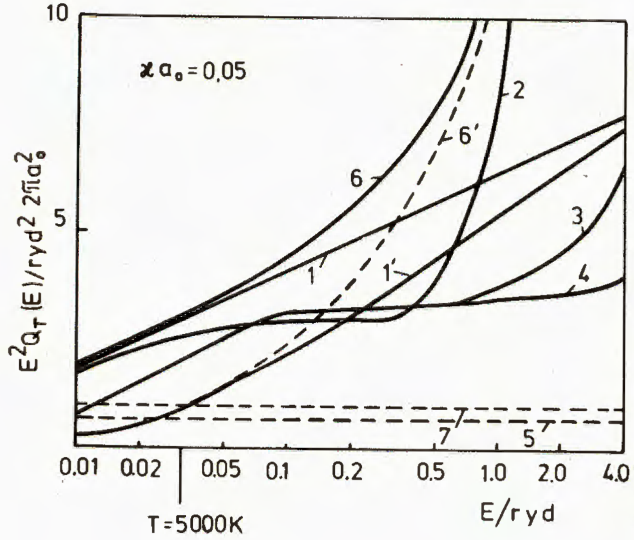

Fig.3. The electron-ion transport cross section $E^2Q_T(E)$ *in 1st Born approximation (2.6) as a function of the energy* E *compared with the other approaches at a density of* κa_0 *= 0.05; (1)-(6) see fig.1, (7) plasma model (4.1)* [18], *(1´) phase shift calculation for the Debye potential* [23,28] *(6´) phase shift calculation for Mayevs Thomas-Fermi potential* [20].

identical results are obtained. That means that the choice of V_0 ($V_0^{(A)}=0$, $V_0^{(HA)} \neq 0$) is of minor importance for the resulting transport cross sections.

Figure 3 shows the transport cross sections resulting from the PPs (1-6) compared with other approaches for a density of $\kappa a_0 = 0.05$ ($n_e = 2\cdot 10^{19} cm^{-3}$) as a function of the energy. The two broken lines (5) and (7) indicate results which are obtained by suiting the PPs to the actual plasma conditions. The Glauberman-Yuchnowsky potential (5) contains a parameter B, which was fitted with the help of equation (3.5) to the mean kinetic energy of the particles at a given temperature (T = = 5000K was chosen throughout the paper).

The other curve (7) is obtained, if the integration in the formula for the transport cross section (2.6) is limited to the inverse Landau-length $1/\ell$ which is considered to characterize the maximum transfer momentum for a given temperature. Then, using the Debye potential (3.1), one obtains the following result for the transport cross section [18], see also [28,29]

$$E^2Q_T(E)=\ln(1+18/\Gamma^2), \quad \Gamma=\frac{\ell}{r_D}>1. \qquad (4.1)$$

This expression is valid for strong nonideal plasmas $\Gamma>1$ and is often regarded to reflect the experimental data well [18]. The conditions used in this paper ($\kappa a_0 = 0.05$, T = 5000K) yield a nonideality parameter of $\Gamma \approx 3$.

Both curves (5) and (7) show the same qualitative behaviour as the Ashcroft (3) and Heine-Abarenkov- (4) potential and lie a little bit below them.

The other two curves in fig.3 (1´, 6´) demonstrate the influence of higher scattering effects. These transport cross sections were obtained by performing a phase shift calculation for the Debye potential [23,28] (1´) and the Thomas-Fermi potential of Mayev [20] (6´) and applying equation (2.4). Hahn et al. [24] have an approximate formula which reproduces the phase shift results of [23] in the low-energy region E < 1 ryd. For higher energies E > 1 ryd, the phase shift calculations converge against the corresponding Born approximation results (1) and (6). However, in the low-energy region E < 1 ryd is obtained a great discrepancy between these two approaches. The Born approximation yields results which are 2...3 times larger than those of the phase shift calculations. This overestimation will lead to transport properties which are too small compared with experiments [11,25]. The consideration of the 2nd Born approximation [26,27] by solving the Lippmann-Schwinger equation (2.5) will alternatively extend the validity of the Born series into the region of lower energies.

Notice that for the temperature T = 5000K which was used in this paper the phase shift calculations (1´, 6´) and the Born approximation with the PPs (5-5) as well as the plasma model (4.1) (curve (7)) lead to nearly identical results.

5. CONCLUSIONS

The transport cross sections for elastic electron-ion-scattering in alkali-plasmas were calculated in 1st Born approximation for different pseudo-potentials and were compared with other approaches.

In the low-energy region E < 0.1 ryd which is characteristic of non-ideal alkali-plasmas [18,30], the use of the Ashcroft (3.3) and the Heine-Abarenkov potential (3.4) leads to a strong decrease of the transport cross sections compared with the results of the Debye (3.1) and Hellmann potential (3.2) (see figs.2 (A-C)). Furthermore, these results are in relative-good agreement with phase shift calculations for the Debye and Thomas-Fermi potential (curves (1´), (6´) in figs.2(A-C) and the simple plasma model (4.1) (curve (7)) in this energy region. It is expected that the corresponding phase shift calculations for the Ashcroft and Heine-Abarenkov potential will lead to a further decrease of the transport cross sections. Therefore, both methods (PPM, phase shift calculation) which represent the influence of the ion structure and of higher scattering effects on the transport cross sections, will lead to an increase of the related transport properties compared with the 1st Born approximation result for the Debye potential in this energy-range (T < 15000K). Thus, a better agreement with experimental data[11,30] can be achieved by applying the concept of weak PPs (Ashcroft-Heine-Abarenkov and Glauberman-Yuchnowski potential) in the low-energy region.

For high energies E > 1 ryd, where the Born results are in good agreement with the phase shift calculations, the transport cross sections are strong-dependent on the choice of the PP. The model of weak short-range interaction (Ashcroft, Heine-Abarenkov, Glauberman-Yuchnowski) leads to results which are much smaller than those of the Thomas-Fermi model of strong attraction (curve (6)) or the Hellmann model of hard-core repulsion (curve (2)) for short distances. In this energy-region which characterizes high-temperature plasmas ($T > 10^5 K$) is obtained a relative decrease of the electrical conductivity compared with plasmas of lower temperatures [11] and *. Therefore, the model of weak PPs will fail to describe the effects of strong Coulomb nonideality in this energy-range. It is expected, for those high-temperature plasmas, that the Thomas-Fermi model, which allows for penetration effects of the scattered electrons into the ions and thus leads to a stronger attraction compared with the potential of a singly charged ion, can describe this relative decrease of the electrical conductivity[11,20].

Notice, that the influence of neutral bound states on the transport properties is important for dense, low-temperature plasmas and has to be included in the theoretical approach in order to obtain a satisfactory agreement with experimental data. The effects connected with the occurrence of neutral bound states (reduction of the number of charge carriers, additional scattering processes with these neutral bound states) are extensively discussed, e.g., in refs.[1,2,11,25-30] and were not considered in this paper. Here, only the influence of different models for the electron-ion interaction on the transport properties was investigated which corresponds to the model of a fully ionized plasma.

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*The same nonideality parameter.

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Вниманию организаций и лиц, заинтересованных в получении публикаций Объединенного института ядерных исследований

Принимается подписка на препринты и сообщения Объединенного института ядерных исследований.

Установлена следующая стоимость подписки на 12 месяцев на издания ОИЯИ, включая пересылку, по отдельным тематическим категориям:

ИНДЕКС	ТЕМАТИКА	Цена подписки на год
1.	Экспериментальная физика высоких энергий	10 р. 80 коп.
2.	Теоретическая физика высоких энергий	17 р. 80 коп.
3.	Экспериментальная нейтронная физика	4 р. 80 коп.
4.	Теоретическая физика низких энергий	8 р. 80 коп.
5.	Математика	4 р. 80 коп.
6.	Ядерная спектроскопия и радиохимия	4 р. 80 коп.
7.	Физика тяжелых ионов	2 р. 85 коп.
8.	Криогеника	2 р. 85 коп.
9.	Ускорители	7 р. 80 коп.
10.	Автоматизация обработки экспериментальных данных	7 р. 80 коп.
11.	Вычислительная математика и техника	6 р. 80 коп.
12.	Химия	1 р. 70 коп.
13.	Техника физического эксперимента	8 р. 80 коп.
14.	Исследования твердых тел и жидкостей ядерными методами	1 р. 70 коп.
15.	Экспериментальная физика ядерных реакций при низких энергиях	1 р. 50 коп.
16.	Дозиметрия и физика защиты	1 р. 90 коп.
17.	Теория конденсированного состояния	6 р. 80 коп.
18.	Использование результатов и методов фундаментальных физических исследований в смежных областях науки и техники	2 р. 35 коп.
19.	Биофизика	1 р. 20 коп.

Подписка может быть оформлена с любого месяца текущего года.

По всем вопросам оформления подписки следует обращаться в издательский отдел ОИЯИ по адресу: 101000 Москва, Главпочтамт, п/я 79.

Редмер Р. E17-85-936

Вычисление транспортных сечений в плазме щелочных металлов методом псевдопотенциалов

Транспортные сечения упругого рассеяния электронов на ионах в плазме щелочных металлов были вычислены в борновском приближении. Влияние короткодействующих сил было исследовано методом псевдопотенциалов. Явные результаты приводятся для транспортных сечений упругого рассеяния электронов на ионах для натрия с применением потенциалов Геллманна, Ашкрофта, Хейне - Абаренкова и Глауберман - Юхновского. Результаты сравниваются с моделями Дебая и Томаса - Ферми для взаимодействия заряженных частиц и с результатами вычисления сдвигов фаз рассеяния. С учетом этих эффектов можно оценить величину электрической проводимости и достичь лучшего согласия с экспериментальными данными в областях низких $E < 0{,}1$ ryd и высоких $E > 1{,}0$ ryd энергий по сравнению с результатами модели Дебая.

Работа выполнена в Лаборатории теоретической физики ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна 1985

Redmer R. E17-85-936

Transport Cross Sections for Alkali Plasmas Using the Pseudo-Potential Method

The electron-ion transport cross sections for alkali plasmas were calculated within the 1st Born approximation. The influence of short-range forces which are due to the ion structure was investigated with the help of the pseudopotential method. Explicit results are shown for the $e-Na^+$ -scattering by applying the Hellmann , Ashcroft , Heine - Abarenkov and Glauberman - Yuchnowski potentials. These results are compared with the standard Debye and the Thomas-Fermi model. Furthermore, the influence of higher scattering effects (calculation of scattering phase shifts) is discussed. The consideration of these effects will lead both in the low-energy region $E < 0.1$ ryd and in the high-energy region $E > 1$ ryd to a better agreement with experimental data for the electrical conductivity compared with the 1st Born approximation within the Debye model.

The investigation has been performed at the Laboratory of Theoretical Physics, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1985